The Administrator signed the CAFO Final Rule on December 15, 2002. EPA is submitting this rule for publication in the Federal Register. While we've taken steps to ensure the accuracy of this Internet version of the rule, it's not the official version of the rule for purposes of compliance. Upon publication you will be able to obtain the official copy of this regulation at http://www.epa.gov/npdes/caforule or at the Federal Register web site.

As noted, today's rule makes no changes to the existing regulations concerning how facilities may make CBI claims with respect to information they must submit to the permitting authority and how those claims will be evaluated. Any changes to how the Agency handles the issue of confidential business information are beyond the scope of today's rule and would have broad implications across a number of EPA programs. Instead EPA will evaluate future CBI claims based on the applicable laws and regulations (see, e.g., CWA Section 402(j), 40 CFR Part 2, Subpart B, and 40 CFR 122.7.

VII. ENVIRONMENTAL BENEFITS OF THE FINAL RULE

A. Summary of the environmental benefits

This section presents EPA's estimates of the environmental and human health benefits, including pollutant reductions, that will occur from this rule. Table 7.1 shows the annualized benefits EPA projects will result from the revised ELG requirements for Large CAFOs. (Monetized values for benefits associated with the revised NPDES requirements for Small and Medium CAFOs are not included in the table.) The total monetized benefits associated with the ELG requirements for Large CAFOs range from $204 to $355 million annually. The values presented in the range represent those benefits for which EPA is able to quantify and determine an economic value. These benefit value estimates reflect only those pollutant reductions and water quality improvements attributable to Large CAFOs. EPA also developed estimates of the pollutant reductions that will occur due to the revised requirements for Small and Medium CAFOs, but analysis of the monetized value of the associated water quality improvements was not completed in time for benefits estimates to be presented here. As discussed later in this section, EPA has also identified additional environmental benefits that will result from this rule but is unable to attribute a specific economic value to these additional nonmonetized or nonquantified benefits.

Detailed information on the estimated pollutant reductions is provided in the Technical Development Document, which is in the docket for today's rule. EPA's detailed assessment of the environmental benefits that will be gained by this rule, as well as the benefits estimates for other regulatory options considered during this rulemaking, is presented in the Benefits Analysis, which is also available in the rulemaking docket.

Table 7.1. Annualized Benefits of ELG Requirements for Large CAFOs (millions of 2001$)

Types of Benefits	Total for all CAFOs
Recreational and non-use benefits from improved water quality in freshwater rivers, streams, and lakes	$166.2 to $298.6
Reduced fish kills	$0.1
Improved shellfish harvests	$0.3 to $3.4
Reduced nitrate contamination of private wells	$30.9 to $45.7
Reduced eutrophication & pathogen contamination of coastal & estuarine waters [Case study of potential fishing benefits to the Albemarle-Pamlico estuary)	not monetized [$0.2]
Reduced public water treatment costs	$1.1 to $1.7
Reduced livestock mortality from nitrate and pathogen contamination of livestock drinking water	$5.3
Reduced pathogen contamination of private & public underground sources of drinking water	not monetized
Reduced human & ecological risks from antibiotics, hormones, metals, salts	not monetized

Types of Benefits	Total for all CAFOs
Improved soil properties	not monetized
Reduced cost of commercial fertilizers for non-CAFO operations	not monetized
Total Benefits	$204.1 + [B] to $355.0 + [B]

[B] represents non-monetized benefits of the rule.

B. What pollutants are present in manure and other CAFO wastes, and how do they affect human health and the environment?

1. What pollutants are present in animal waste?

The primary pollutants associated with animal wastes are nutrients (particularly nitrogen and phosphorus), organic matter, solids, pathogens, and odorous/volatile compounds. Animal waste is also a source of salts and trace elements and, to a lesser extent, antibiotics, pesticides, and hormones. The composition of manure at a particular operation depends on the animal species, size, maturity, and health, as well as on the composition (e.g., protein content) of animal feed. The sections below introduce the main constituents in animal manure and include information from the National Water Quality Inventory: 2000 Report (hereinafter the "2000 Inventory"). This report is prepared every 2 years under § 305(b) of the Clean Water Act, and it summarizes State reports of impairment to their water bodies and the suspected sources of those impairments.

a. Nutrients

Animal wastes contain significant quantities of nutrients, particularly nitrogen and phosphorus. The <u>2000 Inventory</u> lists nutrients as the leading stressor of impaired lakes, ponds, and reservoirs. Nutrients are also ranked as the fifth leading stressor for impaired rivers and streams, are among the top 10 stressors of impaired estuaries, and are the second leading stressor reported for the Great Lakes. Manure nitrogen occurs in several forms, including ammonia and nitrate. Ammonia and nitrate have fertilizer value for crop growth, but these forms of nitrogen can also produce adverse environmental impacts when they are transported in excess quantities to the environment. Ammonia is of environmental concern because it is toxic to aquatic life and it exerts a direct BOD on the receiving water, thereby reducing dissolved oxygen levels and the ability of a water body to support aquatic life. Excessive amounts of ammonia can lead to eutrophication, or nutrient overenrichment, of surface waters. Nitrate is a valuable fertilizer because it is biologically available to plants. Excessive levels of nitrate in drinking water, however, can produce adverse human health impacts.

Phosphorus is of concern in surface waters because it is a nutrient that can lead to eutrophication and the resulting adverse impacts—fish kills, reduced biodiversity, objectionable tastes and odors, increased drinking water treatment costs, and growth of toxic organisms. At concentrations greater than 1.0 milligrams per liter, phosphorus can interfere with the coagulation process in drinking water treatment plants thus reducing treatment efficiency. Phosphorus is of particular concern in fresh waters, where plant growth is typically limited by phosphorus levels. Under high pollutant loads, however, fresh water may become nitrogen-limited. Thus, both nitrogen and phosphorus loads can contribute to eutrophication.

b. Organic matter

Livestock manures contain many carbon-based, biodegradable compounds. Once these compounds reach surface water, they are decomposed by aquatic bacteria and other microorganisms. During this process dissolved oxygen is consumed, which in turn reduces the amount of oxygen available for aquatic animals. The 2000 Inventory indicates that low dissolved oxygen levels caused by organic enrichment (oxygen-depleting substances) are the third leading stressor in impaired estuaries. They are the fourth greatest stressor in impaired rivers and streams, and the fifth leading stressor in impaired lakes, ponds, and reservoirs. Severe reductions in dissolved oxygen levels can lead to fish kills. Even moderate decreases in oxygen levels can adversely affect water bodies through decreases in biodiversity characterized by the loss of fish and other aquatic animal populations, and a dominance of species that can tolerate low levels of dissolved oxygen.

c. Solids

The 2000 Inventory indicates that dissolved solids are the fourth leading stressor in impaired lakes, ponds, and reservoirs. Solids from animal manure include the manure itself and any other elements that have been mixed with it. These elements can include spilled feed, bedding and litter materials, hair, and feathers. In general, the impacts of solids include increasing the turbidity of surface waters, physically hindering the functioning of aquatic plants and animals, and providing a protected environment for pathogens. Increased turbidity reduces penetration of light through the water column, thereby limiting the growth of desirable aquatic plants that serve as a critical habitat for fish, shellfish, and other aquatic organisms. Solids that settle out as bottom deposits can alter or destroy habitat for fish and benthic organisms. Solids also provide a medium for the accumulation, transport, and storage of other pollutants, including nutrients, pathogens, and trace elements.

d. Pathogens

Pathogens are defined as disease-causing microorganisms. A subset of microorganisms, including species of bacteria, viruses, and parasites, can cause sickness and disease in humans and are known as human pathogens. The 2000 Inventory indicates that pathogens (specifically bacteria) are the leading stressor in impaired rivers and streams and the fourth leading stressor in impaired estuaries. Livestock manure may contain a variety of microorganism species, some of which are human pathogens. Multiple species of pathogens can be transmitted directly from a host animal's manure to surface water, and pathogens already in surface water can increase in number because of loadings of animal manure nutrients and organic matter.

More than 150 pathogens found in livestock manure are associated with risks to humans, including the six human pathogens that account for more than 90% of food and waterborne diseases in humans. These organisms are: Campylobacter spp., Salmonella spp. (non-typhoid), Listeria monocytogenes, Escherichia coli O157:H7, Cryptosporidium parvum, and Giardia lamblia. All of these organisms may be rapidly transmitted from one animal to another in CAFO settings. An important feature relating to the potential for disease transmission for each of these organisms is the relatively low infectious dose in humans. The protozoan species Cryptosporidium parvum and Giardia lamblia are frequently found in animal manure. Bacteria such as Escherichia coli O157:H7 and Salmonella spp. are also often found in livestock manure and have been associated with waterborne disease. The bacteria Listeria monocytogenes is ubiquitous in nature and is commonly found in the intestines of wild and domestic animals.

e. Other potential contaminants

Animal wastes can contain other chemical constituents that could adversely affect the environment. These constituents include salts, trace elements, and pharmaceuticals, including antibiotics and hormones. Although salts are usually present in waste regardless of animal or feed type, trace elements and pharmaceuticals are typically the result of feed additives to help prevent disease or promote growth. Accordingly, concentrations of these constituents vary with operation type and from facility to facility. The other constituents present in animal wastes are summarized below. Additional information on animal wastes is presented in the preamble for the proposed rule (see 66 FR 2976-2979) and the Technical Development Document.

Salts. The salinity of animal manure is directly related to the presence of dissolved mineral salts. In particular, significant concentrations of soluble salts containing sodium and potassium remain from undigested feed that passes unabsorbed through animals. Other major constituents contributing to manure salinity are calcium, magnesium, chloride, sulfate, bicarbonate, carbonate, and nitrate. Salt buildup may deteriorate soil structure, reduce permeability, contaminate ground water, and reduce crop yields. In fresh waters, increasing salinity can disrupt the balance of the ecosystem, making it difficult for resident species to remain. Salts may also contribute to degradation of drinking water supplies.

Trace elements. The 2000 Inventory indicates that metals are the leading stressor in impaired estuaries and the second leading stressor in impaired lakes. Trace elements in manure that are of environmental concern include arsenic, copper, selenium, zinc, cadmium, molybdenum, nickel, lead, iron, manganese, aluminum, and boron. Of these, arsenic, copper, selenium, and zinc are often added to animal feed as growth stimulants or biocides. Trace elements can also end up in manure through use of pesticides, which are applied to livestock to suppress houseflies and other pests. Trace elements have been found in manure lagoons and in drainage ditches, agricultural drainage wells, and tile line inlets and outlets. They have also been found in rivers adjacent to hog and cattle operations. Trace elements in agronomically applied manures are generally expected to pose little risk to human health and the environment. However, repeated application of manures above agronomic rates could result in cumulative metal loadings to levels that potentially affect human health and the environment. There is some evidence that this is happening. For example, in 1995, zinc and copper were found building to potentially harmful levels on the fields of a hog farm in North Carolina.

Antibiotics. Antibiotics are used in AFOs and can be expected to appear in animal wastes. Antibiotics are used both to treat illness and as feed additives to promote growth or to improve feed conversion efficiency. Between 60 and 80 percent of all livestock and poultry receive antibiotics during their productive lifespan. The primary mechanisms of elimination are in urine and bile, so essentially all of an antibiotic administered is eventually excreted, whether unchanged or in metabolite form. Little information is available regarding the concentrations of antibiotics in animal wastes, or on their fate and transport in the environment. One concern regarding the widespread use of antibiotics in animal manure is the development of antibiotic-resistant pathogens. Use of antibiotics, especially broad-spectrum antibiotics, in raising animals is increasing. This could be contributing to the emergence of more strains of antibiotic-resistant pathogens, along with strains that are growing more resistant.

Pesticides and hormones. Pesticides and hormones are compounds used at AFOs and they can be expected to appear in animal wastes. These types of pollutants may be linked with endocrine disruption. The 2000 Inventory indicates that pesticides are the second leading stressor in impaired estuaries. Pesticides are applied to livestock to suppress houseflies and other pests. There has been very little research on losses of pesticides in runoff from manured lands. A 1994 study showed that losses of cyromazine (used to control flies in poultry litter) in runoff increased with the rate of poultry manure and litter applied and the intensity of rainfall. Specific hormones are used to increase productivity in the beef and dairy industries. Several studies have shown hormones are present in animal manures. Poultry manure has been shown to contain both estrogen and testosterone. Runoff from fields with land-applied manure has been reported to contain estrogens, estradiol, progesterone, and testosterone, as well as their synthetic counterparts. In 1995, an irrigation pond and three streams in the Conestoga River watershed near the Chesapeake Bay had both estrogen and testosterone present. All of these sites were affected by fields receiving poultry litter.

2. How do these pollutants reach surface waters?

Pollutants in animal waste and manure can enter the environment through a number of pathways, including surface runoff and erosion, direct discharges to surface water, spills and other dry-weather discharges, leaching into soil and ground water, and volatilization of compounds (e.g., ammonia) and subsequent redeposition to the landscape. These discharges of manure pollutants can originate from animal confinement areas, manure handling and containment systems, manure stockpiles, and cropland where manure is spread.

Runoff and erosion occur during rainfall when rainwater fails to be absorbed into the ground and when the soil surface is worn away by water or wind. Runoff of animal wastes is more likely when rainfall occurs soon after application (particularly if the manure was not injected or incorporated) and when manure is overapplied or misapplied. Erosion can be a significant transport mechanism for land applied pollutants, such as phosphorus, that are strongly bonded to soils.

Pollutants are directly discharged to surface water when animals are allowed access to water bodies and when manure storage areas overflow. Dry weather discharges to surface waters associated with CAFOs have been reported to occur through spills or other accidental discharges from lagoons and irrigation systems, or through intentional releases. Other reported causes of discharge to surface waters are overflows from containment systems following rainfall, catastrophic spills from failure of manure containment systems, and washouts from floodwaters when lagoons are sited on floodplains or from equipment malfunction, such as pump or irrigation gun failure, and breakage of pipes or retaining walls.

It is well established that in many agricultural areas shallow ground water can become contaminated with manure pollutants. This occurs as a result of water traveling through the soil to the ground water and taking with it pollutants such as nitrate from livestock and poultry wastes on the surface. Leaking lagoons are also a potential source of manure pollutants in ground water, based on findings reported in the scientific and technical literature.

Pollutants from CAFO wastes are released to air through volatilization of manure constituents and the products of manure decomposition. Other ways that manure pollutants can enter the air is from spray irrigation systems and as wind-borne particulates in dust. Once airborne, these pollutants can find their way into nearby streams, rivers, and lakes as they are subsequently redeposited on the landscape. More detailed information on the transport of animal wastes is presented in the Benefits Analysis and the record.

3. How is water quality impaired by animal wastes?

EPA has made significant progress in implementing Clean Water Act programs and in reducing water pollution. Despite such progress, however, serious water quality problems persist throughout the country. Sources of information on these problems include reports from States to EPA, documented in the 2000 Inventory, and the U.S. Geological Survey's National Water Quality Assessment (NAWQA) Program.

a. EPA's National Water Quality Inventory

Agricultural operations, including CAFOs, are a significant contributor to the remaining water pollution problems in the United States, as reported by the 2000 Inventory. EPA's 2000 Inventory data indicate that the agricultural sector—including crop production, pasture and range grazing, concentrated and confined animal feeding operations, and aquaculture— is the leading contributor to identified water quality impairments in the nation's rivers and streams, lakes, ponds, and reservoirs. Agriculture is also identified as the fifth leading contributor to identified water quality impairments in the nation's estuaries. While the 2000 Inventory does not generally separate effects of CAFOs from agriculture generally, EPA's data indicate that water quality concerns tend to be greatest in regions where crops are intensively cultivated and where livestock operations are concentrated.

The 2000 Inventory data indicate that the agricultural sector contributes to the impairment of at least 129,000 river miles, 3.2 million lake acres, and more than 2,800 estuarine square miles. Forty-eight States and tribes identified agricultural sector activities contributing to water quality impacts on rivers; 40 States identified such impacts to lakes, ponds, and reservoirs; and 14 States reported such impacts on estuaries. AFOs are only a subset of the agriculture category, but 29 States specifically identified them as contributing to water quality impairment.

The leading pollutants impairing surface water quality in the United States as identified in the 2000 Inventory data include nutrients, pathogens, sediment/siltation, and oxygen-depleting substances. These pollutants can originate from various sources, including the animal production industry. Animal production facilities may also discharge other pollutants, such as metals and pesticides, and can contribute to the growth of noxious aquatic plants due to the discharge of excess nutrients.

These data provide a general indication of national surface water quality, highlighting the magnitude of water quality impairment from agriculture and the relative contribution compared to other sources. Moreover, the findings of this report are corroborated by numerous reports and studies conducted by government and independent researchers that identify agriculture's predominance as an important contributor of surface water pollution, as summarized in the Environmental Assessment of Revisions to the National Pollutant Discharge Elimination System Regulation and the Effluent Guidelines for Concentrated Animal Feeding Operations, which is available in EPA's rulemaking record.

b. Other documented impacts on water quality

Data collected by NAWQA also identify agriculture among the leading contributor of nutrients to U.S. watersheds. A national water quality assessment program conducted by the U.S. Geologic Survey found that agricultural use of fertilizers, manure, and pesticides has degraded stream and shallow ground water quality in agricultural areas and has resulted in high concentrations of nitrogen. Subsequent measurements in specific major river basins suggest that animal feeding operations may play a significant role in observed water quality degradation in those basins (e.g., Kalkhoff et al., 2000; Groschen et al., 2000). Finally, a 1997 study by Smith et al. characterizing spatial and temporal patterns in water quality identified animal waste as a significant source of in-stream nutrient concentrations in many watershed outlets, relative to other local sources, particularly in the central and eastern United States. The findings of this report suggest that livestock waste contributes more than commercial fertilizer use to local total phosphorus yield, whereas the use of commercial fertilizer is the leading source of local total nitrogen yield.

Numerous local, regional, and national evaluations also indicate that animal manure can be a significant source of pollutants that contribute to water quality degradation. A literature survey conducted for the proposed rule identified more than 150 reports of discharges to surface waters from hog, poultry, dairy, and cattle operations. Over 30 separate incidents of discharges from swine operations between the years 1992 and 1997 in Iowa alone were reported by that State's Department of Natural Resources.

The incidents resulted in fish kills ranging from about 500 to more than 500,000 fish killed per event. Fish kills or other environmental impacts have also been reported by agencies in other States, including Nebraska, Maryland, Ohio, Michigan, and North Carolina.

Runoff of nutrients and other contaminants in animal manure and wastewater also contributes to degradation of U.S. waters. For example, nutrients originating from livestock and poultry operations in the Mississippi River Basin have been identified as contributing to the largest hypoxic zone in U.S. coastal waters in the northern Gulf of Mexico. (Hypoxia is the condition in which dissolved oxygen is below the level necessary to sustain most animal life.) According to a report conducted by the National Science and Technology Council in 2000, adverse impacts of eutrophication might be of concern for ecologically and commercially important species in the Gulf, whose fishery resources generate $2.8 billion annually. Animal manure also contributes to eutrophication, or nutrient overenrichment, which is also a serious concern for the Nation's coastal and estuarine resources.

More detailed information is presented in the 2001 proposal (66 FR 2972-2974) and in the record for this rulemaking.

4. What ecological and human health impacts have been caused by CAFO wastes?

Among the reported environmental problems associated with animal manure are surface and ground water quality degradation, adverse effects on estuarine water quality and resources in coastal areas, and effects on soil and air quality. The scientific literature, which spans more than 30 years, documents how these problems can contribute to increased risk to aquatic and wildlife ecosystems, for example, the large number of fish kills in recent years. Human health might also be affected, for example, by high nitrate levels in drinking water and exposure to waterborne human pathogens and other pollutants in manure. The record for this rule provides more detailed information on the scientific and technical research to support these findings.

a. Ecological impacts

Manure pollutants in surface waters contribute to eutrophication, the disruption of a water body due to overenrichment. Eutrophication is the most documented impact of nutrient pollution and is a serious concern for coastal and estuarine resources. Another negative impact generated by excess nutrients in surface water is algae blooms, which also result from overenrichment from nutrients. Such blooms depress oxygen levels and contribute further to eutrophication. Many lake and coastal problems are linked to eutrophication, including red tides, fish kills, outbreaks of shellfish poisonings, loss of habitat, coral reef destruction, and hypoxia.

Many of the constituents in manure, especially organic matter, also decrease the oxygen concentrations in surface waters, sometimes below the levels fish and invertebrates require to survive. Nitrites and pathogens in manure can also pose risks to aquatic life. If sediments are enriched by nutrients, the concentrations of nitrites in the overlying water may be raised enough to cause nitrite poisoning in fish. There is substantial information in the record for this rule that describes local, regional, and national evaluations indicating that animal manure is a significant source of pollutants that contribute to water quality degradation. Many of these evaluations note a high incidence of fish kills. EPA's analysis shows that between 1981 and 1999, 19 States reported 4 million fish killed from both runoff and spills at CAFOs.

In addition, excess nitrogen can contribute to water quality decline by increasing the acidity of surface waters. Pathogens can accumulate in fish and shellfish, resulting in a pathway for transmission to higher trophic organisms; they can also contribute to avian botulism and avian cholera. Additional information on fish kills and other adverse impacts is presented in the 2001 proposal (66 FR 2972-2974) and in the record for this rulemaking.

b. Human health impacts from affected drinking water

Pollution originating from an animal production facility can have multiple impacts on drinking water. Nitrogen in manure is easily transformed into the nitrate form, which can be transported to drinking water sources and present a range of health risks. These health risks include methemoglobinemia in infants, spontaneous abortions, and increased incidence of stomach and esophageal cancers. Nitrate is not removed by conventional drinking water treatment processes but requires additional, relatively expensive treatment units. California's Chino Basin estimates a cost of more than $1 million per year to remove nitrates from drinking water due to loadings from local dairies. Generally, people drawing water from domestic wells are at greater risk of nitrate poisoning than those drawing from public water sources, because domestic wells are typically shallower and not subject to wellhead protection monitoring or treatment requirements.

Salts in animal wastes can also pose a health hazard. At low levels, salts can increase blood pressure in salt-sensitive individuals, increasing their risk of stroke and heart attacks. The salt load into the Chino Basin from local dairies is more than 1,500 tons per year, which costs the drinking water treatment system between $320 and $690 per ton to remove.

To the extent that nutrients contribute to algae blooms in surface water through accelerated eutrophication, algae can affect drinking water by clogging treatment plant intakes, producing objectionable tastes and odors, and increasing production of harmful chlorinated by-products (e.g., trihalomethanes) by reacting with chlorine used to disinfect drinking water. In Wisconsin, the City of Oshkosh has spent an extra $30,000 per year on copper sulfate treatment to kill the algae in the waters from Lake Winnebago, which is attributed to excess nutrients from animal manure, commercial fertilizers, and soil. In Tulsa, Oklahoma, excessive algae growth in Lake Eucha, associated with poultry farming, costs the city $100,000 per year to address taste and odor problems in the drinking water.

c. Other human health impacts

In addition to threats to human health through drinking water exposures, pathogens from animal manure can also threaten human health through shellfish consumption and recreational contact such as swimming in contaminated waters. Relatively low-dose exposures to Cryptosporidium parvum and Giardia spp. can cause infection in humans. Other bacteria found in livestock manure have also been associated with waterborne disease. Pathogens from animal wastes can readily enter water sources, resulting in contamination of surface waters. Some pathogens are able to survive and remain infectious in the environment for relatively long periods of time. U.S. federal agencies and other independent researchers have recognized the potential public health risks from pathogens originating from CAFOs. At this time, however, the magnitude of the human health risk from pathogenic organisms that directly originate from CAFOs and are transported through U.S. waters has not been established.

According to a United Nations report, the use of antibiotics in food-producing animals has the potential to affect human health because of the presence of drug residues in foods and also because of the selection of resistant bacteria in animals. However, the impact of antimicrobial metabolic products and nonmetabolized drugs in animal wastes that are released into the environment remains unclear. The emergence of resistant bacteria is of particular concern because such infections are more difficult to treat and require drugs that are often less readily available, more expensive, and more toxic. In the U.S., pilot studies coordinated by EPA, USDA, and the Centers for Disease Control have been initiated to assess the extent of environmental contamination by antimicrobial drug residues and drug-resistant organisms that enter the soil or water from human and animal waste.

C. How will water quality and human health be improved by this rule?

1. What reductions in pollutant discharges will result from this rule?

EPA's pollutant reductions for this rule focus to a large degree on estimating the amount of pollutants in the runoff from land where manure has been applied. These estimates of pollutant discharges, referred to as the "edge-of-field" loadings, were made for nutrients, metals, pathogens, and sediment for both pre-rule conditions (baseline) and post-rule conditions. The reductions in pollutant discharges were estimated using an environmental model (Groundwater Loading Effects of Agricultural Management Systems, or GLEAMS) that simulates hydrologic transport, erosion, and biochemical processes such as chemical transformation and plant uptake. The GLEAMS model uses information on soil characteristics and climate, along with characteristics of the applied manure and commercial fertilizers, to model losses of nutrients, metals, pathogens, and sediment in surface runoff, sediment, and ground water leachate. EPA's analysis also developed estimates of changes in pollutant discharges occurring at the production area.

The pollutant reduction estimates were developed for each type of model farm included in EPA's cost models. The model farms were developed to represent the various animal types, farm sizes, and geographic regions. Model farms were developed for each animal type across a range of size classes, and model farms were located in each geographic region. The pollutant estimates for the model farms were combined with published data from USDA's 1997 Census of Agriculture and then refined into national, regional, State, and county level pollutant loading estimates that were used to determine in-stream surface water and ground water concentrations. These values were then used in the water quality models and other environmental benefits assessment models to estimate the human health and environmental benefits accruing from this rule.

EPA quantified the reduction of nitrogen and phosphorus loads associated with this rule. Reductions of discharges of the metals zinc, copper, cadmium, nickel, lead, and arsenic were also analyzed for the final rule. Fecal coliform and fecal streptococcus were used as surrogates to estimate pathogen reductions that would be achieved by this rule. Other pathogens would likely be reduced to a similar degree. Table 7.2 presents the pollutant reductions expected to result from this rule.

Table 7.2. Pollutant reductions: Combined total for all animal sectors

Parameter	Baseline Pollutant Loading (Pre-regulation)	Post-regulation Pollutant Loading	Pollutant Reduction
Large CAFOs			
Nutrients (million lb)	658	503	155 (24%)
Metals (million lb)	20	19	1 (5%)
Pathogens (10^{19} cfu)	5,784	3,129	2,655 (46%)
Sediment (million lb)	35,493	33,434	2,059 (6%)
Medium CAFOs			
Nutrients (million lb)	65	54	11 (17%)
Metals (million lb)	2.0	1.9	0.1 (5%)

Pathogens (10^{19} cfu)	1,456	779	677 (46%)
Sediment (million lb)	3,119	3,015	104 (3%)

2. Approach for determining the benefits of this rule

EPA has analyzed the water quality improvements expected to result from the new requirements being promulgated today and has estimated the environmental and human health benefits of the pollutant reductions that will result. The benefits described in this section are primarily associated with direct improvements in water quality (both surface water and ground water), but this new rule will also create certain non-water quality environmental effects, such as improved soil conditions, changes in energy consumption, and changes in emissions of air pollutants.

For this rule, EPA conducted seven benefit studies to estimate the impacts of reductions in pollutant discharges from CAFOs. The first study used a national water quality model (National Water Pollution Control Assessment Model, or NWPCAM) that estimates runoff from land application areas to rivers, streams, and, to a lesser extent, lakes in the U.S. This study estimated the value society places on improvements in surface water quality associated with today's rule. The second study examined the expected improvements in shellfish harvesting resulting from the new CAFO rule. A third study looked at incidences of fish kills that are attributed to AFOs and estimated the cost of replacing the lost fish stocks. The fourth study estimated the benefits associated with reduced ground water contamination. Reduced public water treatment costs were evaluated in the fifth study, and reduced livestock mortality from nitrate and pathogen contamination of livestock drinking water was evaluated in the sixth study. In the seventh study, a case study of potential fishing benefits for the Albemarle-Pamlico estuary is presented to provide some insight to the potential benefits for estuaries and coastal waters. Each of the seven studies, as well as benefits results, are briefly described in the following sections. Benefits results associated with reduced pollutant discharges from Large CAFOs are also summarized in Table 7.1. The benefit value estimates presented in this section reflect only those pollutant reductions and water quality improvements attributable to Large CAFOs. EPA also developed estimates of the pollutant reductions that will occur due to the revised requirements for Small and Medium CAFOs, but analysis of the monetized value of the associated water quality improvements was not completed in time for benefits estimates to be presented here.

In this analysis, EPA estimates the effect of pollutant reductions and other environmental improvements on human health and the ecosystem and assigns a monetary value to these benefits to the extent possible. In some cases, EPA was able to identify certain types of improvements that will result from this rule, but was unable to either estimate the monetary value of the improvement or quantify the amount of improvement that will occur. These non-monetized and non-quantified benefits are included in the discussion below. Given the limitations in assigning monetary values to some of the improvements, the economic benefit values described below and in the Benefits Analysis should be considered a subset of the total benefits of this rule. These monetized benefits should be evaluated along with descriptive qualitative assessments of the non-monetized benefits. For example, the economic valuation used for this rule assigns monetary values to the water quality improvements due to reductions of the most significant pollutants originating from CAFOs (e.g., nitrogen, phosphorus, pathogens, and sediment), but it does not include values for potential water quality improvements expected due to reduced discharges of certain other pollutants discharged in lesser amounts, such as metals or hormones.

Research documented in the record and summarized in the Benefits Analysis shows that CAFO wastes may affect the environment and human health in a variety of ways beyond those for which benefits have been monetized. The following are examples of other types of potential impacts or potential benefits:

- human health and ecological effects of metals, antibiotics, hormones, salts, and other pollutants associated with CAFO manure
- eutrophication of coastal and estuarine waters due to both nutrients in runoff and deposition of ammonia volatilized from CAFOs
- reduced human illness due to pathogen exposure during recreational activities in estuaries and coastal waters
- improvements to soil properties due to reduced overapplication of manure, together with increased acreage receiving manure applications at agronomic rates
- reduced pathogen contamination in private drinking water wells
- reduced cost of commercial fertilizers for non-CAFO operations

EPA's Benefits Analysis does not include monetary values for these other areas of environmental improvements because data limitations preclude quantifiable estimates of the magnitude of improvement or it is difficult to ascribe an economic value to these benefits. Nevertheless, these environmental benefits may result in improved ecological conditions and reduced risk to human health.

3. Benefits from improved surface water quality

a. Freshwater recreational benefits

EPA used NWPCAM to estimate the national economic benefits to surface water quality that will result as CAFOs implement the requirements of this rule. NWPCAM is a national-scale water quality model that simulates the water quality and benefits for various water pollution control approaches. NWPCAM is designed to characterize water quality for the Nation's network of rivers and streams, and, to a more limited extent, its lakes. NWPCAM can translate spatially varying water quality changes (improvements or degradation) resulting from different pollution control policies into terms that reflect the value individuals place on water quality improvements. In this way, NWPCAM is able to derive the economic benefit of the water quality improvements that will result from reducing CAFO discharges.

For this rule, EPA used NWPCAM to simulate impacts due to reductions in pollutant loadings from Large CAFOs (nitrogen, phosphorus, pathogen indicators, BOD5, and TSS) on water quality in the Nation's surface waters. NWPCAM's national-scale framework allows hydraulic transport, routing, and connectivity of surface waters to be simulated for the entire continental United States with the exception of coastal and estuarine waters. Pollutant loadings from the CAFOs were used as inputs to NWPCAM. The CAFO loadings were processed through the NWPCAM water quality modeling system to estimate in-stream pollutant concentrations on a detailed spatial scale to provide estimates of changes in water quality that will result as CAFOs implement this new rule. The NWPCAM modeling output, simulating the improved water quality in the Nation's surface waters, was used as the basis for monetizing improvements to water quality, and as input to several of the other benefits analyses described later in this section.

The monetary value of the benefits associated with the changes in water quality are estimated using two valuation techniques. The first technique relates water quality changes to changes in the category of use the water quality can support (e.g., boatable uses versus fishable uses, or fishable uses versus swimmable uses), also referred to as the "water quality ladder" approach, and also considers the size of population benefitting from the changes in the types of use the water quality can support. The second method is similar to the first, but it uses a composite measure of water quality that is calculated from six water quality parameters (referred to as the "water quality index" approach). A key difference in the two approaches is that the water quality ladder approach assesses improvements using a step-function that attributes a monetary value to the water quality improvement only when changing from one use category to another (e.g., a change from boatable use to fishable use), while the water quality index method assigns values along a continuum of water quality improvement (e.g., the water use may remain designated as "boatable use," but improvements within that use category are assigned a monetary value). For both valuation approaches, the monetary value assigned to the benefits is based on what the public is willing to pay for improvements to water quality.

Based on the NWPCAM analysis using the water quality ladder approach, the benefits of improved surface water quality resulting from reduced pollutant discharges from Large CAFOs are estimated to be $166 million annually (2001 dollars). Using the water quality index approach, the benefits of improved surface water quality are estimated at $298 million annually (2001 dollars).

b. Shellfish beds

Pathogen contamination of coastal waters is a leading cause of shellfish bed harvest restrictions and closures. Sources of pathogens include runoff from agricultural land and activities. Using The 1995 National Shellfish Register of Classified Growing Waters published by the National Oceanic and Atmospheric Administration, EPA estimated the improvements to shellfish bed harvesting that will result as CAFO discharges of pathogens are reduced by this rule. These data were used to determine the average per-acre yield of shellfish from harvested waters and to estimate the area of shellfish-growing waters that are currently unharvested as a result of pollution from AFOs. By combining the per-acre yield data with estimates of the acreage of currently unharvested shellfish beds that will become available for harvesting as discharges of pathogens from Large CAFOs are reduced, EPA calculates the value of improved shellfish harvests at $0.3 to $3.4 million annually.

c. Fish kills

Episodic fish kill events resulting from spills, manure runoff, and other discharges of manure from AFOs continue to remain a serious problem in the United States. The impacts from these incidents range from immediate and dramatic kill events to less dramatic but more widespread events. Manure dumped into and along the West Branch of the Pecatonica River in Wisconsin resulted in a complete kill of smallmouth bass, catfish, forage fish, and all but the hardiest insects in a 13-mile stretch of the river. Less immediate, but equally important, catastrophic impacts on water quality from manure runoff are increased algae growth or algae blooms, which remove oxygen from the water and can result in the death of fish. Manure runoff into a shallow lake in Arkansas resulted in a heavy algae bloom that depleted the lake of oxygen, killing many fish.

While the modeled estimates of surface water quality improvements have been used to monetize benefits associated with freshwater bodies, water quality modeling (i.e., NWPCAM) does not include estuaries, coastal areas or other marine water bodies, and fish kills are noted to occur in these areas as well. Parts of the Eastern Shore of the United States have been plagued with problems related to Pfiesteria, a dinoflagellate algae that exist in rivers at all times, but is known to cause fish kills in estuarine and coastal environments under certain conditions. Fish attacked by Pfiesteria have lesions or large, gaping holes on them as their skin tissue is broken down; the lesions often result in death. The conditions under which Pfiesteria can harm fish are believed to be related to high levels of nutrients. Fish kills related to Pfiesteria in the Neuse River in North Carolina have been blamed on the booming hog industry and the associated waste spills and runoff from the hog farms. Preliminary evidence suggests that human health problems might also be associated with exposure to Pfiesteria. As a result, people most likely would limit or avoid recreational activities in coastal waters with Pfiesteria-related fish kills. The town of New Bern, a popular summer vacation spot along the Neuse River in North Carolina, experienced several major fish kills in the summer of 1995. During this event, people became ill after swimming and fishing in the impacted areas, and there were reports that people swimming in the waters reported welts and sores on their bodies. Summer camps canceled boating classes, children were urged to stay out of the water, and warnings were issued about swimming and eating fish that were diseased. Many blame the heavy rainfall, which pumped pollutants from overflowing sewage plants and hog lagoons into the river, creating algae blooms, low oxygen, and Pfiesteria outbreaks as the cause of the fish kills.

EPA obtained reports on fish kill events in the United States, with data for nineteen States showing historical and current fish kills. Using these data, EPA estimates the benefits of reducing fish kills through implementation of the ELG requirements in today's rule for Large CAFOs at $0.1 million annually.

d. Reduced public water treatment costs

Total suspended solids (TSS) entering the surface waters from CAFOs can hinder effective drinking water treatment by interfering with coagulation, filtration, and disinfection processes. EPA used the NWPCAM model to predict how pollutant reductions from Large CAFOs would affect the ambient concentration of TSS in the source waters of public water supply systems. To measure the value of reductions in TSS concentrations, EPA estimated the extent to which lower TSS concentrations reduce the operation and maintenance (O&M) costs associated with the conventional treatment technique of gravity filtration. EPA estimates reduced drinking water treatment costs of $1.1 to $1.7 million annually due to reduced discharges of pollutants at Large CAFOs.

4. Benefits from improved ground water quality

a. Human health benefits

CAFO wastes can contaminate ground water and thereby cause health risks and welfare losses to people relying on ground water sources for their potable supplies or other uses. Of particular concern are nitrogen and other constituents that leach through the soils and the unsaturated zone and ultimately reach ground waters. Nitrogen loadings convert to elevated nitrate concentrations at household and community system wells, and elevated nitrate levels in turn pose a risk to human health in households with private wells. (Nitrate levels in community wells are regulated to protect human health.)

This rule is expected to reduce nitrate levels in private drinking wells by reducing the rate at which manure is spread on cropland, thus reducing the rate at which pollutants will leach through soils and reach ground water. The federal health-based National Primary Drinking Water Standard for nitrate is 10 milligrams per liter (mg/L), and this Maximum Contaminant Level (MCL) applies to all community water supply systems. Households relying on private wells are not subject to the federal MCL for nitrate, but levels above 10 mg/L are considered unsafe for sensitive subpopulations (e.g., infants). Several economic studies indicate a considerable willingness-to-pay by households to reduce the likelihood of nitrate levels exceeding 10 mg/L, and to reduce nitrate levels even when baseline concentrations are considerably below the MCL.

EPA used U.S. Geological Survey data on nitrate levels in wells throughout the country to predict how nitrate concentrations in private drinking wells would be reduced by this rule. Based on these data, EPA estimates that 9.2 percent of households that currently rely on private wells with nitrate concentrations exceeding the MCL will have these concentrations reduced to levels below the MCL because of the ELG requirements for Large CAFOs. EPA estimates the value of these reductions based on willingness-to-pay studies to be $583 annually per household (2001$) resulting in benefit estimates of $30.2 to $44.6 million nationally on an annual basis for this component of ground water improvements. Another 5.8 million households that currently have nitrate levels in their private wells below the MCL will experience further reductions in nitrate levels because of the ELG requirements for Large CAFOs. Studies also show that people are willing to pay $2.09 per mg/L reduced annually (2001$) to get these additional reductions once they are already below the MCL for nitrate. This gives benefits estimates of $0.7 million to

$1.1 million annually for the nation for this component of ground water improvements. The total benefits of reduced nitrate contamination of private drinking wells as a result of reducing pollutant discharges at Large CAFOs are estimated to range from approximately $30.9 to $45.7 million annually (2001$).

Research documented in the record and summarized in the Benefits Analysis shows that CAFO wastes affect the environment and human health in ways beyond those for which benefits have been monetized. Additional ground water benefits that may result from this rule include reduced pathogen contamination of private drinking water wells and community drinking water supplies. EPA's Benefits Analysis does not include monetary values for these additional ground water improvements because data limitations preclude quantifiable estimates of the magnitude of improvement or because it is difficult to ascribe an economic value to these benefits. EPA also recognizes that CAFO operators have strong private incentives to avoid contaminating their own private drinking water sources.

b. Animal health benefits

Land application of manure can result in leaching of nitrates and enteric pathogens to ground water, which in many cases is used as the source of drinking water for livestock in rural communities. Excessive nitrate in livestock watering sources, particularly in conjunction with feeds containing nitrogen such as alfalfa, can contribute to increased morbidity and mortality due to acute and chronic nitrate poisoning in cattle which would have the ability to convert nitrate to toxic nitrite. In addition, studies have found that nearly 20% of rural water wells are contaminated with enteric pathogens such as fecal coliform and fecal streptococcus, common indicators of enteric pathogens, at ratios which suggest the source of contamination may be animal waste. Consumption of water by livestock contaminated with enteric pathogens could result in increased morbidity and mortality due to waterborne illness, particularly gastrointestinal disorders.

EPA used data from scientific literature, USDA data on beef and dairy mortality from poisoning and gastrointestinal illness, EPA data on rural groundwater quality, and published recommendations for livestock drinking water quality, to estimate the potential to reduce on-farm beef and dairy cattle mortality associated with pathogens and nitrates in ground water. From this, EPA estimated the avoided cost of replacing cattle mortalities. The ELG requirements are expected to reduce nitrate and pathogen contamination of ground water at Large CAFOs and, as a result, reduce annual cattle mortality from nitrate poisoning and pathogens at Large CAFOs by approximately 4,300 mature cattle and 3,900 calves. Using a replacement value of $1,185 for mature cattle and $54 for day-old calves (2002 dollars), the monetary benefit of reduced on-farm beef and dairy cattle mortality at Large CAFOs is estimated at $5.3 million annually.

D. Other (non-water quality) environmental impacts and benefits

In analyzing the effects of this rule, EPA also considered how the requirements promulgated today would affect the amount and form of compounds released to air, as well as the energy that is required to operate the CAFO. In addition to the water quality impacts and benefits discussed above, EPA's analyses for this rule have also evaluated these other types of environmental impacts, often referred to as non-water quality environmental impacts. These non-water quality environmental impacts include changes in air emissions from CAFO production areas and land where CAFO-generated manure is spread, changes in energy use, and improvements in soil properties. EPA's estimates of changes in air emissions and energy use are described in more detail in the Technical Development Document.

To assess the potential changes in air emissions resulting from this rule, EPA quantified the releases from the production area, including animal housing and animal waste storage and treatment areas; land application activities; and emissions from vehicles, including the off-site transport of waste and on-site composting operations.

EPA projects increased emissions of criteria air pollutants (particulate matter, volatile organic compounds, nitrogen oxides, and carbon monoxide) related to increased fuel consumption as excess manure is transported away from the CAFO. The contribution of these projected increases is limited compared to the national criteria pollutant inventory. For example, for the year 2000, the total national inventory for nitrogen oxides was 25 million tons. The contribution of the projected increase in CAFO emissions of nitrogen oxides is less than 0.01 percent of that amount. The national inventory values for other criteria pollutants are also much larger than the projected changes in emissions from CAFOs.

CAFOs are a source of ammonia, which is a contributor to the formation of fine particulate matter. This rule is not expected to significantly alter ammonia emissions from CAFOs. During the rulemaking, EPA evaluated a number of regulatory options and, as part of those analyses, considered the potential air quality benefits associated with changes in ammonia emissions. For further discussion of those analyses, refer to Chapter 13 of the <u>Technical Development Document</u> and Section 22 of the rulemaking record.

CAFOs are also a source of hydrogen sulfide emissions. EPA's calculations indicate that today's rule will reduce hydrogen sulfide emissions from Large CAFOs by 12 percent nationally. Reductions in hydrogen sulfide emissions are expected to lead to human health benefits, but EPA has not been able to calculate the economic value of these reductions.

Finally, CAFOs are a source of greenhouse gases. Emissions of nitrous oxide at CAFOs arise mainly from the feedlot area during denitrification of nitrogen compounds during waste storage on the drylot and from fields where animal wastes are land applied. Emissions of methane also mainly arise during waste storage, created during the anaerobic decomposition of carbon compounds. CAFOs currently contribute approximately 3 percent of all U.S. nitrous oxide emissions and a similar percentage of U.S. methane emissions. EPA estimates that emissions of nitrous oxide at Large CAFOs will increase by 4 percent as the requirements of today's rule are implemented, and emissions of methane will decrease by 11 percent.

EPA also expects that the properties of the soil at a number of land application areas might improve because of reduced overapplication of manure. The soil properties of cropland that does not currently receive manure, but becomes a recipient as additional manure is hauled away from CAFOs that have excess manure are also expected to benefit from the organic matter content (improving tilth) and the micronutrients present in manure.

VIII. COSTS AND ECONOMIC IMPACTS

This section presents EPA's estimate of the total annual costs and the economic impacts that would be incurred by the livestock and poultry industry as a result of today's rule. This section also discusses EPA's estimated effects on small businesses and presents the results of the Agency's cost-effectiveness and cost-benefit analysis. All costs presented in this section are reported in pre-tax 2001 dollars (unless otherwise indicated).

EPA estimates the total monetized social costs of the final regulations at about $335 million annually. These costs include compliance costs borne by CAFOs and also administrative costs to federal and State governments. EPA estimates the total compliance cost for Large CAFOs at $283 million per year (pre-tax, $2001). Costs to Medium CAFOs are estimated at $39 million per year. Costs to Medium and Small operations that are designated as CAFOs are estimated at $4 million per year. EPA